RESEARCH ARTICLE

Do Antibiotic Beads Need to be Removed?

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Abstract

Background: Polymethylmethacrylate antibiotic impregnated beads can be an effective treatment for chronic osteomyelitis or an adjuvant in the treatment of open fractures. It remains unclear however whether the beads cause long-term adverse events if not removed. The purpose of this study was to determine if removal of antibiotic beads was required in order to avoid long term complications.

Methods: A retrospective chart review was conducted on patients with an extremity or pelvis fracture that had implantation of polymethylmethacrylate (PMMA) antibiotic beads over a five-year period.

Results: Fifty-one patients met inclusion criteria for this study; thirty-seven patients (73%) did not have complications after surgical debridement and placement of PMMA antibiotic beads necessitating removal.

Conclusion: Our findings suggest that polymethylmethacrylate antibiotic beads can be utilized as a means of delivering high-dose concentrations of local antibiotics and do not have to be removed in all patients.

Level of evidence: III

Keywords: Antibiotics, Antibiotic beads, Antibiotic resistance, Fracture, Infection

Introduction

Infections traverse every subspecialty in orthopaedics and continue to be a challenge to treat (1-4). Open fractures have be shown to be at a higher risk of infection in comparison to closed fractures, which may progress to osteomyelitis as well as contribute to non-union (5-7). High concentrations of antibiotics can be delivered through the use of polymethylmethacrylate (PMMA) impregnated beads placed locally within the wound, and typically demonstrate less systemic effects in comparison to intravenous antibiotics (8). This has the additional benefit of antibiotic delivery without the same degree of patient compliance typically necessary with intravenous delivery. Klemm was the first to publish on the use of polymethylmethacrylate antibiotic beads in 1979, and achieved a 91.4 % cure rate of chronic osteomyelitis when used in conjunction with surgical debridement (9). It remains unclear however whether retention of PMMA beads cause long-term adverse events if not removed. Although beads can continue to release antibiotics for months to decrease bacterial burden, they may also theoretically serve as a substratum for bacteria particularly after elution is complete (10, 11). Because of this theoretical concern, many surgeons routinely schedule a staged procedure for bead removal. Clearly there are independent medical and surgical risks, as well as costs both to the patient and health care system associated with performing an additional operation. The aim of this study was to determine if routine removal of antibiotic beads after extremity or pelvic fracture was required in order to avoid long-term complications.

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Materials and Methods

A retrospective review of prospectively gathered data at a Level I regional trauma center was conducted on patients with an extremity or pelvis fracture that had implantation of PMMA antibiotic beads over a five-year period. The beads were premade by the pharmacy utilizing a bead template tray. The antibiotics impregnated within the PMMA beads were either vancomycin or tobramycin. The operative reports were reviewed to determine the plan for antibiotic bead management and noted as to whether there was a predetermined plan for removal. Exclusion criteria included patients who were less than 18 years old, had less than three months of follow up, and patients treated in staged surgical manner with planned bead removal. Patient's electronic charts were reviewed to evaluate for clinical evidence of infection or painful beads based on history or physical examination. Operative reports and intra-operative culture data were reviewed of the patents who had removal of beads to determine if persistence of infection, new infection and/or antibiotic resistance was noted.

Results

Three hundred and seventy patients had antibiotic-impregnated PMMA beads placed by an orthopaedic surgeon at our institution during the study period. Fifty-one patients met inclusion criteria for our study. The majority of patients who were excluded were done so due to planned staged surgical management or lack of at least three months of follow-up. Fifty-one percent of fractures were open and most commonly involving the tibia (72.5%). Sixty percent of patients had PMMA antibiotic beads placed in the acute or subacute fracture healing phase. Average follow-up was 35 weeks (range of 12-269 weeks).

Thirty-seven patients (73%) did not undergo bead removal, and there were no wound complications at long-term follow-up (range 6 months-5 years). Four patients (7.8%) had complete wound healing without a bead related complication but had removal during fracture non-union repair or total joint arthroplasty. In patients with complete wound healing prior to removal, there was no purulence found intra-operatively during PMMA bead removal and intraoperative cultures were negative. Fourteen patients (27%) underwent unplanned surgical bead removal. Eleven of those patients had delayed wound healing and removal within 90 days of placement during repeat surgical debridement. Two patients (3.9%) had removal because of PMMA bead protuberance in areas of thin subcutaneous tissue causing pain [Figure 1]. No patients developed resistance on subsequent cultures; one patient had progression to a polymicrobial infection without change in bacterial resistance. Another patient eradicated a methicillin-resistant Staphylococcus aureus infection, but with subsequent isolation of Serratia marcescens on cultures during bead removal.

Discussion

Open fractures and osteomyelitis are challenging and costly diagnoses to treat. Adequate treatment of osteomyelitis and hardware biofilm requires antibiotic concentrations of 10 to 100 times the usual bactericidal concentration (12). Often this cannot be achieved safely with parenteral antibiotics (12). When PMMA antibiotic bead concentrations are measured in animal models at the site of a seroma/hematoma, granulation tissue, and bone, values exceeded the minimum inhibitory concentration (MIC) breakpoints of targeted pathogens (13). When used in Gustilo type III fractures, PMMA antibiotic beads decrease the rates of infection when compared to systemic antibiotics alone (14). The bead configuration can also have better elution properties

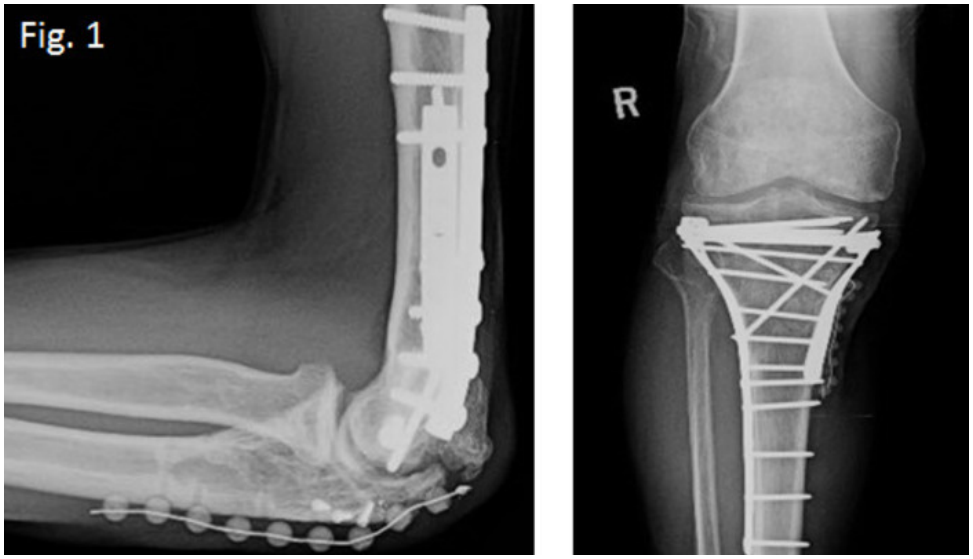

Figure 1. Radiographs of patients who had symptomatic beads. Patient on left had beads placed posterior to proximal ulna. Patient on right had beads placed on medial face of tibia.

when compared to cement blocks because of increased available surface area (11). Local delivery of antibiotics can therefore be a safer alternative or adjuvant to high dose parenteral therapy (10, 15).

Of the fourteen patients in our study that required a repeat unplanned surgical debridement, eleven were revised due to delayed wound healing. Conversely, this suggests that if the beads are placed and the wound goes on to heal, the surgeon should be confident future wound problems requiring debridement are unlikely.

Polymethylmethacrylate antibiotic beads may also need to be removed for reasons not related to delayed wound healing. In our series, two patients required removal due to discomfort secondary to location of antibiotic bead placement. One of the patients had beads placed on the medial proximal tibia and the other had beads placed close to the olecranon. This suggest that If PMMA antibiotic beads are placed in areas with minimal overlying subcutaneous tissue, patients may present with persistent pain. In these scenarios, it is reasonable to remove the beads to reduce pain and prevent skin irritation. The PMMA antibiotic beads may also need to be removed prior to non-union fracture repair or joint replacement, the latter in particular to minimize the potential for third-body wear of the bearing surface.

Prior literature has raised concern that not removing PMMA beads may predispose to the development of bacterial resistance. In a case report of a patient with implanted PMMA gentamycin beads who underwent removal at five years, drug concentrations were still measurable, although at sub-inhibitory levels (11). Furthermore, when cultures were taken of the beads, gentamycin-resistant bacteria were isolated. In our study, no patient developed drug resistance on subsequent cultures, although one patient had progression to a polymicrobial infection without a change in bacterial resistance. The culture data from this study does not support the development of drug resistance related to PMMA antibiotic beads, however did find there can be progression to polymicrobial infections or identification of bacteria not treated adequately by the antibiotics contained within the beads. Although the use of absorbable calcium-sulfate based antibiotic delivery systems has gained popularity, concerns regarding persistent wound drainage have been reported, and the costs associated may be prohibitive in many health care systems (16, 17).

Due to the retrospective nature of this study a number of limitations exist. One, given our relatively low sample size, we were underpowered to detect rare complications such as recurrent infection or resistance. Furthermore, a significant percentage or patients in our study were excluded due to planned PMMA bead removal, which may represent a selection bias of our analyzed group of patients who were not recommended staged removal. Our study also suggests that a significant percentage of PMMA beads may still need to be removed during repeat surgical debridement for delayed wound healing or in areas of thin subcutaneous tissue, in our study representing a 27% of patients who were not scheduled for a staged bead removal. Although meticulous surgical debridement is the mainstay of treatment in infection, placement of PMMA antibiotic beads can be a potent adjunct.

Polymethylmethacrylate antibiotic beads can be utilized as a means of delivering high dose concentration of local antibiotics. These can be effective in the treatment of acute fractures with gross contamination, subacute/chronic septic non-unions, or late infections with retained hardware. Our data suggests that PMMA beads do not necessarily harbor an environment for recurrent or persistent infection. Furthermore, antibiotic resistance does not appear to be a significant issue with placement of beads. To conclude, routine removal of PMMA beads is not necessary in the majority of patients with pelvis or extremity fractures. The risks and health care costs of second stage surgery should be weighed against the potential for persistent wound drainage or soft tissue irritation if beads are retained.

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